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Refractive Indices and Polarization Parameters for Saturated Silver Phosphate in Mixed (Acetonitrile-H_2O) at Different Temperatures

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The refractive indexes and the densities of saturated solution of saturated silver phosphate in mixed (Acetonitrile-H_2O) solvents were measured at three different temperatures, 298.15K, 303.15K, and 308.15K. From the values of the measured refractive indexes the atomic, electronic polarizations, the molar volumes, polarizabilities and the induced dipole moment were calculated and discussed.

Introduction

Refractive index and density measurements were expected to explain solute – solvent interactions [1-2]. Detection of liquid concentration by optical refractive index was already known in old time [3]. The first laboratory instrument to accurate measure the refractive index of liquids was developed by Ernst Abbe in 1874. Many authors used both refractive index and density to study the ion –solvent and solvent –solvent interactions [3-4], with water [5-7] and other organic solvents [8-10]. Optical measurement technique such as refractive indexes is used in experimental fluid mechanics to investigate pure fluids or dilute suspensions [10-12]. Refractive index plays an important role in many areas of material science with reference to thin film technology and fiber optics.

Similarly, measurement of refractive index is widely used in analytical chemistry to determine the concentration of pollutions [13-16]. The present work includes the estimation of excess refractive indexes, molar volumes, polarizabilities and induced dipole moments for saturated silver phosphate solutions at 298.15K, 303.15K, and 308.15K. The evaluated physical parameters for silver phosphate are important in studying the solvation process [17-21]. Recently high quantum efficiency photocatlyst and photo-corrosion silver phosphate was used [22]. Advanced oxidation processes have been used to purify waste water by oxidation of pollutants using silver phosphate as environmentally friendly photo materials were used [23, 24].

Experimental

Silver phosphate and acetonitrile pure chemicals were supplied from EL. Nasr Pharmaceutical Chemicals Co. The Refractive indexes of saturated solutions of silver phosphate were measured using a refractometer of the type ATAGO 3T. NO 52507 and circulating water were circulated around the prism of refractometer to keep the temperature constant through Ultra-Thermostat of the type of the type (SIBATA-SU-20).

The saturated solutions were prepared by adding the excess amount of the solid acid in 10 ml. of the corresponding solvent mixtures, using closed test tubes.

The solutions were vigorously shaken in the ultra-Thermostat with an output of 30 W of 50 KHZ Frequency.

Results and Discussion

The values of X_{S1}, mole fraction of acetonitrile were calculated by applying equation (1):

$$\frac{\frac{vol\%(1)xd1}{M1}}{\frac{vol\%(1)xd1}{M1}+\frac{vol\%(2)xd2}{M2}}=X_{s1} \quad (1)$$

where d_1, d_2, M_1, M_2, vol%(1) and vol% (2) are the densities, the molecular weights and the volume percentages of the organic solvents acetonitrile and water, respectively. The values of X_{s2} in equation equal to ($1-X_{s1}$).

From measured refractive indices measured values for silver phosphate the molar refraction (R) was calculated using equation (2).

$$R=\frac{n^2-1}{n^2+2}V=P_A+P_E=P_D=P_T \quad (2)$$

Where V is the molar volume of saturated silver phosphate.

The right hand side of equation (2) is equal to the total molar polarization or distortion polarization which equal to the summation of both the electronic polarization (P_E) and atomic polarization (P_A). The atomic (P_E) polarization (P_A) was calculated [25-35].

From equation 3, the values for saturated silver phosphate solutions are sited in Tables 1, 2, and 3 at different temperatures.

$$P_A=1.05\ n^2 \quad (3)$$

The value for molecular polarizability (α) can be calculated from optical refractive index (n) of the saturated silver phosphate solutions containing N molecules per unit volume. The refractive index is related to the polarizability of saturated molecules by Lorenz-Lorenz formula [36-54] as explained in equation (4).

$$\frac{n^2-1}{n^2+2}=\frac{4\,\bar{n}\,\alpha\,\pi}{3} \quad (4)$$

Where $\bar{n}=\frac{N}{V}$, N is Avogadro‘s number and V is the molar volume of saturated silver phosphate solutions. Applying equation (5), the polarizabilities of saturated silver phosphate solutions were calculated at different temperatures and presented in Tables 1, 2, and 3.

The electronic polarization (P_E) can be calculated by using equation (2) on subtracting the atomic polarization values (P_A) from the total polarization (P_T). The dipole moments for saturated silver phosphate solutions induced by the solvent and mixed (acetonitrile-H_2O) solvents were calculated using equation (5) after applying the dielectric constant values with those values of mixed (acetonitrile-H_2O) solvents.

$$\frac{(\varepsilon-n^2)(2\varepsilon-n^2)}{\varepsilon(n^2+2)^2}=\frac{4\,\pi\,N\,g\,\mu^2}{4\,K\,T\,V} \quad (5)$$

In using Onsager solution g =1, which is Onsager cavity field [40-54]. The evaluated induced dipole moments for saturated solutions of silver phosphate in mixed acetonitrile-H_2O solvents were presented in Tables 1, 2, and 3 at different temperatures.

The measured refractive indices (n), the molar refraction (R), the atomic polarization (P_A), electronic polarization (P_E), polarizabilities (α) and induced dipole moments (**μ**) are listed in Tables 1, 2, and 3 at different temperatures. The relation between mole fraction (X_s), (α) and (μ) for silver phosphate in mixed (acetonitrile-H_2O) solvents at 308.15K temperature as example in three and two dimensions are shown in Fig. 1 and 2.

Table 1. *Refraction parameters for saturated silver phosphate in mixed (acetonitrile-H_2O) solvents at 298.15K in different mole fractions of acetonitrile X_{s1}.*

V%	n	Xs_1	PA	PT	PE	R	α	ε	μ
0%	1.3384	0	1.8808	0.2021	-1.678	84.59	3.4x10-23	78.3	2.29x10-22
20%	1.3488	0.07878	1.9102	0.2145	-1.695	89.78	3.5x10-23	74.96	2.23x10-22
40%	1.6360	0.18569	2.8103	0.3584	-2.452	150.1	5.9x10-	70.44	1.75x10-22
60%	1.3531	0.33911	1.9225	0.2169	-1.706	90.78	3.6x10-23	63.94	2.05x10-22
80%	1.3531	0.57772	1.9225	0.2169	-1.706	90.78	3.6x10-23	53.83	1.88x10-22
100%	1.3491	1	1.91107	0.2147	-1.696	89.85	3.56x10-23	35.95	1.53x10-22

Table 2. *Refraction parameters for saturated silver phosphate in mixed (acetonitrile-H_2O) solvents.*

V%	n	Xs_1	PA	PT	PE	R	α	ε	μ
0%	1.3373	0	1.8241	0.2081	-1.616	87.1	3.45x10-23	76.546	2.29x10-22
20%	1.3491	0.07878	1.9111	0.2125	-1.698	88.9	3.5x10-23	73.243	2.22x10-22
40%	1.3521	0.18569	1.9196	0.2163	-1.703	90.5	3.6x10-23	68.764	2.15x10-22
60%	1.3894	0.33911	2.0236	0.2366	-1.790	99	3.9x10-23	62.335	1.98x10-22
80%	1.4396	0.57772	2.1766	0.2633	-1.913	110	4.4x10-23	52.337	1.75x10-22
100%	1.3521	1	1.9193	0.2163	-1.703	90.5	6x10-23	35.641	1.51x10-22

At 303.15K.

Table 3. *Refraction parameters for saturated silver phosphate in mixed (acetonitrile-H_2O) solvents at 308.15K.*

V%	n	Xs_1	PA	PT	PE	R	α	ε	μ
0%	1.3400	0	1.885	0.209	-1.676	87.7	3.5x10x-23	74.83	2.28x10-22
20%	1.3447	0.07878	1.908	0.214	-1.693	89.6	3.6x10-23	71.55	2.21x10-22
40%	1.3521	0.18569	1.919	0.216	-1.703	90.6	3.6x10-23	67.09	2.14x10-22
60%	1.3541	0.33911	1.925	0.217	-1.708	91.0	3.601x10-23	60.71	2.03x10-22
80%	1.3541	0.57772	1.925	0.219	-1.706	91.7	3.63x10-23	50.77	1.85x10-22
100%	1.3601	1	1.943	0.221	-1.722	92.4	3.7x10-23	33.19	1.48x10-22

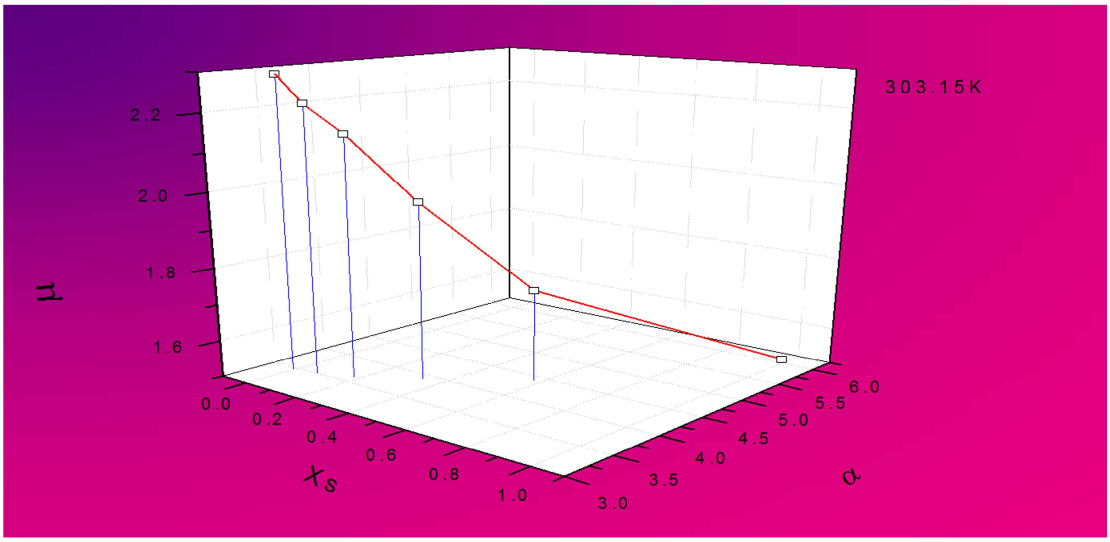

Fig. 1. *The relation between mole fraction of acetonitrile (X_s) =Xs_1, (α) and (μ) for Silver Phosphate in mixed acetonitrile-H_2O solvent at 303.15K.*

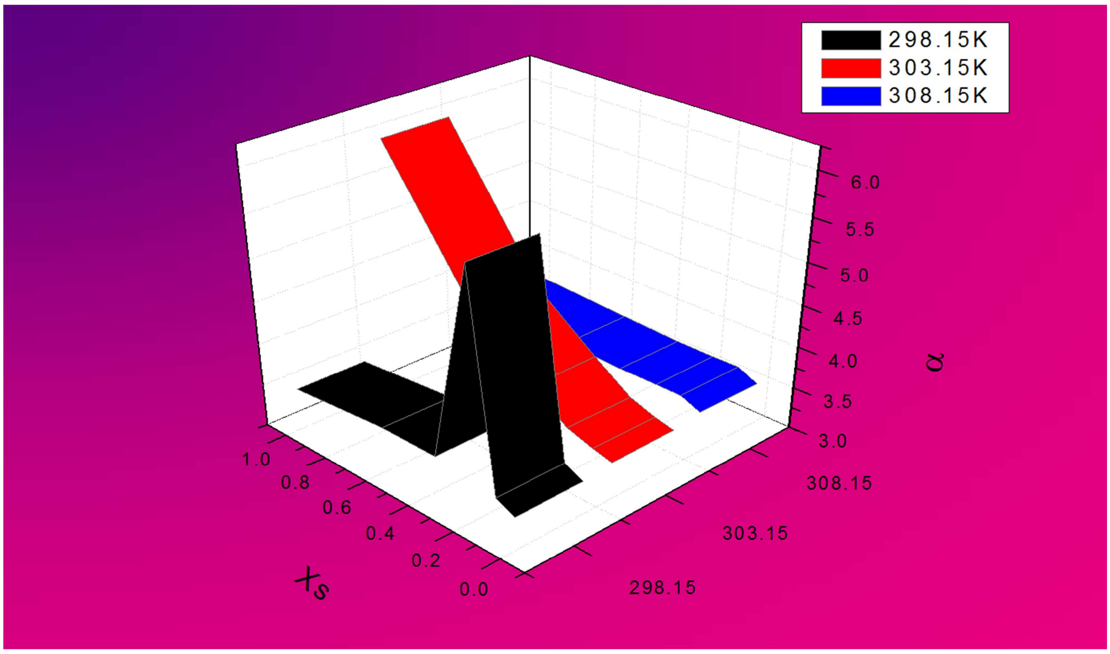

Fig. 2. *The relation between mole fraction of acetonitrile (X_s) =Xs_1 and (α) for Silver phosphate in mixed acetonitrile-H_2O solvent at different temperatures.*

Conclusion

The refractive indices for saturated silver phosphate solutions were increased in mixed (acetonitrile-H_2O) by increasing acetonitrile proportions. All polarization parameters, refractive indices (n), the molar refraction (R), the atomic polarization (P_A), electronic polarization (P_E), polarizabilities (α) and induced dipole moment (μ) for silver phosphate solutions were increased by increasing both acetonitrile and temperature due to more mobility and velocity of ionic species in the used solvents. ■

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